

Research and teaching activities in Nuclear chemistry



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2nd International Training Course on Environmental Radioactivity with Nucleonica
14-16 November 2011, Monaco



Sofia University "St. Kliment Ohridski"

- The first Bulgarian university, founded in 1888;
- The largest and most prestigious educational and scientific centre in both fundamental theoretical and applied areas
- The largest university in the country with 88 degree programmes offered by 16 faculties.



Faculty of Chemistry

Chairs

General and Inorganic Chemistry
Analytical Chemistry
Applied Inorganic Chemistry
Applied Organic Chemistry
Organic Chemistry
Physical Chemistry
Laboratory of Chemical Physics and Engineering

Nuclear chemistry education

- ❑ Bachelor degree of “Nuclear chemistry” – 8 semesters
- ❑ Master degree of “Nuclear chemistry” – 2 semesters (only for bachelors of Nuclear chemistry)
- ❑ Master degree “Radiochemistry and radioecology” – 3 semesters
- ❑ Obligatory course “Radiochemistry” for students of Master degree “Nuclear energetic and technology”

Laboratory of Radiochemistry – II class

Laboratory of Radioanalytical chemistry – III class



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Nuclear chemistry education

Lectures in:

“Nuclear chemistry and radiochemistry”

“Applications of radionuclides in the chemical investigations”

“Radioisotope dating”

“Radiochemistry”

Laboratory practice in:

“Nuclear chemistry and radiochemistry”

“Radioecology”

“Radioanalytical chemistry”

“Chemistry of the nuclear fuel cycle and nuclear reactors”



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Research activities

Mechanochemistry of 5f-elements compounds

Investigation of the effects of the mechanical treatment in planetary ball mill on U- and Th-compounds:

- **Mechanolysis;**
- **Mechanosynthesis;**
- **Leaching behavior of daughter products.**



**Planetary mill
PULVERISETTE 5**

Radioecology

Migration and transfer of natural and technogenic radionuclides in the environment



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Mechanochemistry of 5f-elements compounds

INVESTIGATED COMPOUNDS:

U_3O_8 , UO_3 , ThO_2 , $\text{UO}_2(\text{CH}_3\text{COO})_2 \cdot 2\text{H}_2\text{O}$, $\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$,
 $\text{U}_3\text{O}_8 + \text{ThO}_2$, $\text{U}_3\text{O}_8 + \text{La}_2\text{O}_3$, $\text{U}_3\text{O}_8 + \text{CeO}_2$.

MEDIA OF MECHANOCHEMICAL LOADING:

Stainless steel and Agate triboreactors

Air and suspensions of H_2O , C_6H_6 , $\text{C}_6\text{H}_5\text{CH}_3$, CCl_4 , CH_3CHO

ANALYTICAL METHODS:

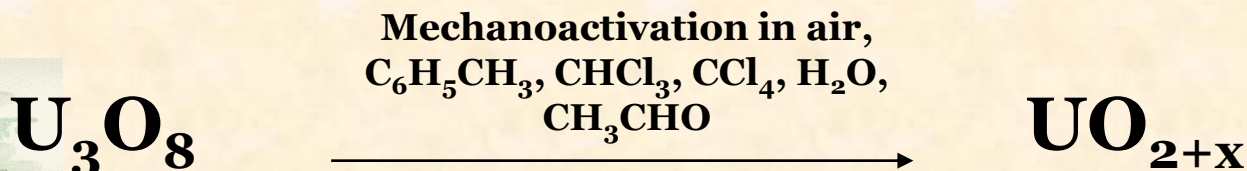
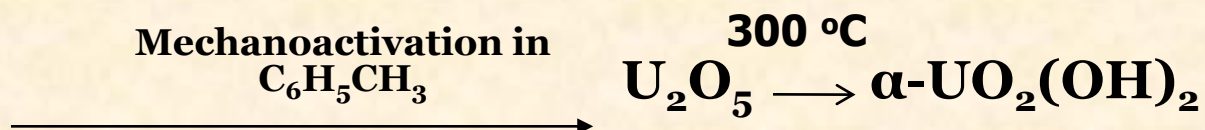
X-ray diffractometry, IR analysis, X-ray fluorescence analysis, Gamma-spectrometry, Liquid scintillation spectrometry



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Mechanochemistry of 5f-elements compounds

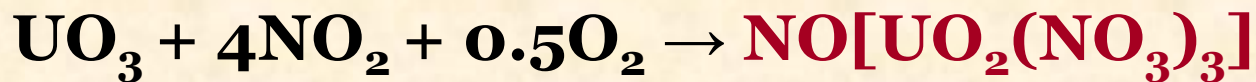
Effects of the mechanochemical activation of U_3O_8 and UO_3 in air and in suspension in stainless steel and agate triboreactors:



Mechanochemistry of 5f-elements compounds

Mechanochemical treatment of $\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ in stainless steel vessels

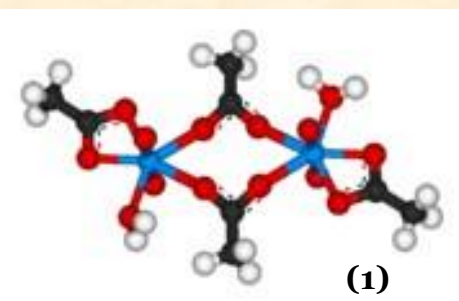
- Partial transformation to nitrosyl uranyl nitrate



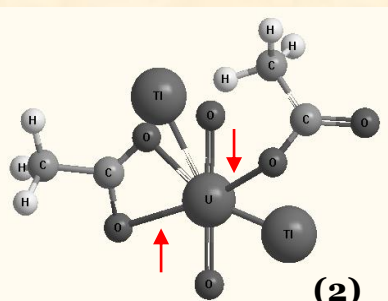
Mechanochemistry of 5f-elements compounds

Mechanochemical treatment of $\text{UO}_2(\text{CH}_3\text{COO})_2 \cdot 2\text{H}_2\text{O}$ in suspension with C_6H_6 or $\text{C}_6\text{H}_5\text{CH}_3$ in stainless steel vessels

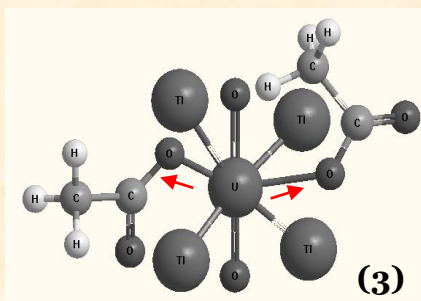
Formation of a U-containing substance found in the toluene medium with change in the coordination mode: Bidentate (helate) type of coordination of CH_3COO^- ligands is partially substituted by a monodentate bonding. The new-formed specie is soluble in non-polar solvents.



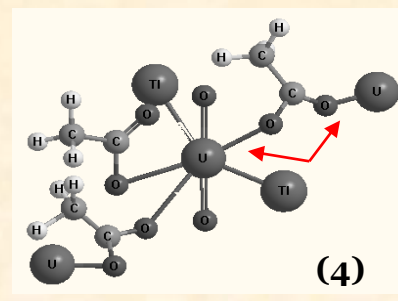
bidentate



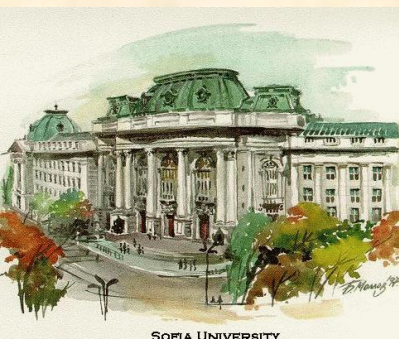
helate-monodentate



monodentate



monodentate-bidentate

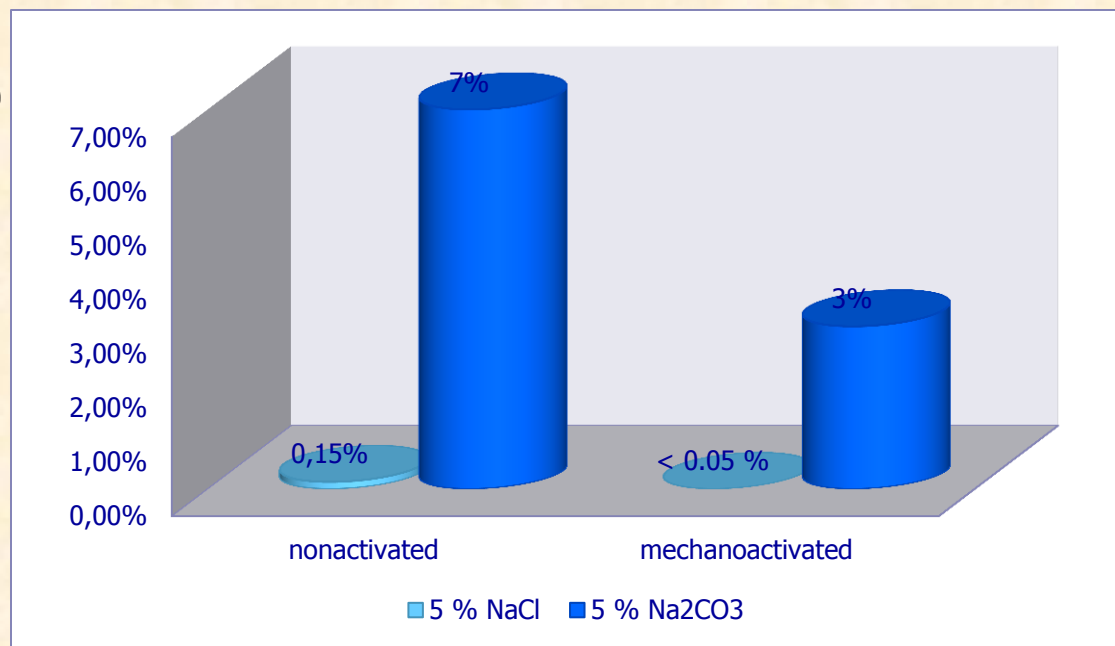


Mechanochemistry of 5f-elements compounds

Leaching behavior of the radionuclides after mechanoactivation:

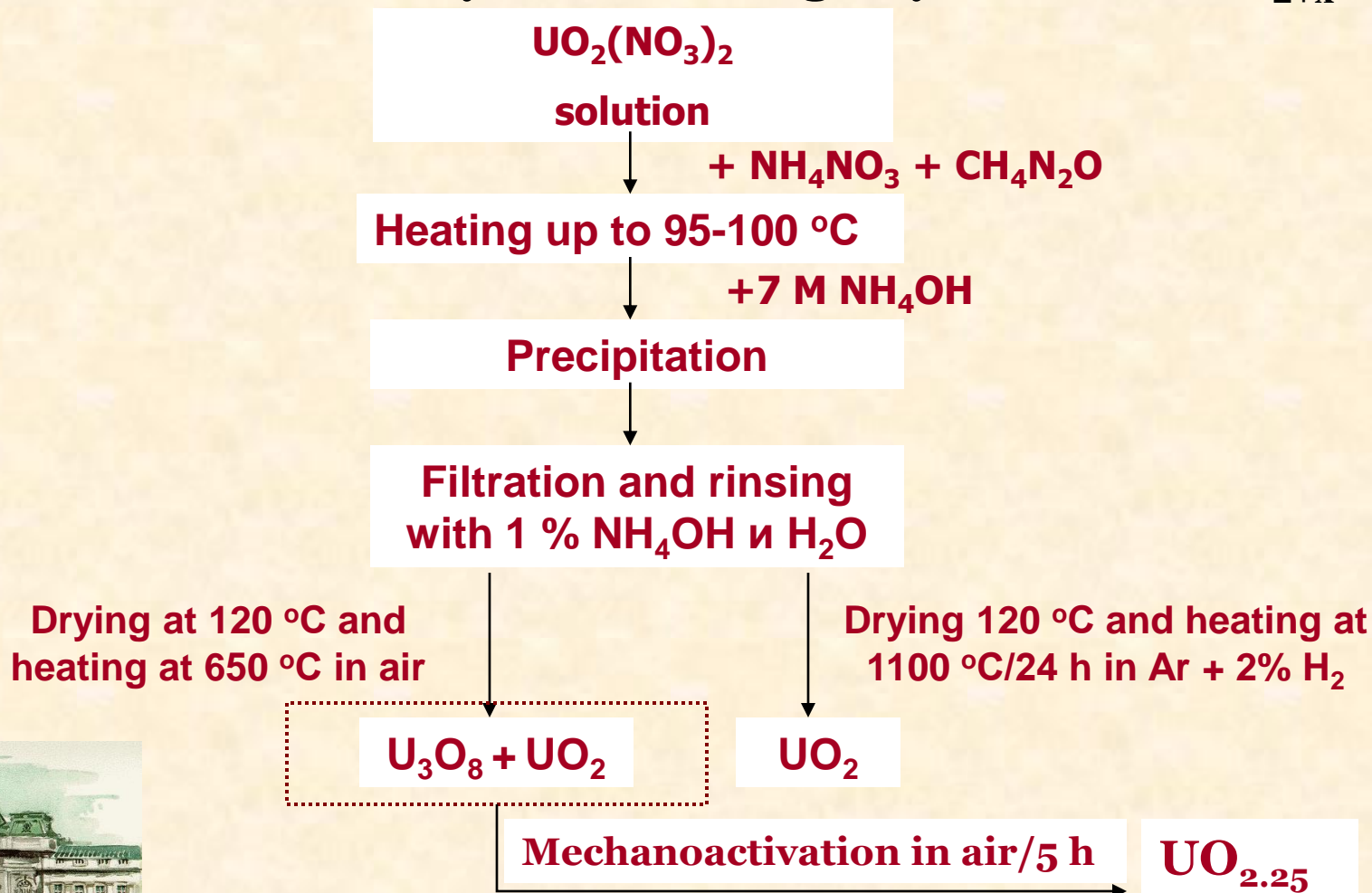
- Increased leaching of U from U_3O_8 ;
- Decreased leaching of ^{234}Th from U_3O_8 ;
- Decreased leaching of ^{212}Pb from ThO_2 .

% leached ^{234}Th /g U



Mechanochemistry of 5f-elements compounds

Mechanochemically assisted sol-gel synthesis of UO_{2+x}



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Mechanochemistry of 5f-elements compounds

Mechanochemically assisted synthesis of Uranium-Thorium and Uranium-Lanthanoids mixed oxides



Use the mechanochemical treatment as an alternative way to obtain uranium-containing mixed oxides at relatively low temperature in air avoiding the usage of atmosphere with controllable composition.



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Migration of natural and technogenic radionuclides in the environment

Influence of the soil characteristics on the chemical fractionation of the radionuclides

Procedures for sequential extraction in order to determine the forms:

- free-bound or exchangeable;
- bound to carbonates;
- associated to Fe and Mn oxides;
- associated to organic matter;
- residual forms.

Determination of transfer coefficients of natural and technogenic radionuclides from different soil types to plants

- Vegetation experiments

Radionuclides: ^{241}Am , ^{60}Co , ^{137}Cs and ^{54}Mn .



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Migration of natural and technogenic radionuclides in the environment

Research project:

“Influence of the climate changes on the migration and bioaccumulation of natural and technogenic radionuclides”,

National Science Fund, Ministry of education youth and science of Bulgaria

- In co-operation with Laboratory of Radiochemistry and Environmental Chemistry at Paul Scherrer Institute

Studies on the effects of the sharp climate changes on:

- fractionation of radionuclides in different soil types;
- transfer factors of element contaminants from soil to plants



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Migration of natural and technogenic radionuclides in the environment

Conditioning of contaminated soils under different climate conditions:

- temperature;
- air humidity;
- soil humidity.

Radionuclides:

^{241}Am , ^{137}Cs , ^{60}Co , ^{54}Mn , ^{22}Na , Th, U, ^{65}Zn .



Humidity chamber



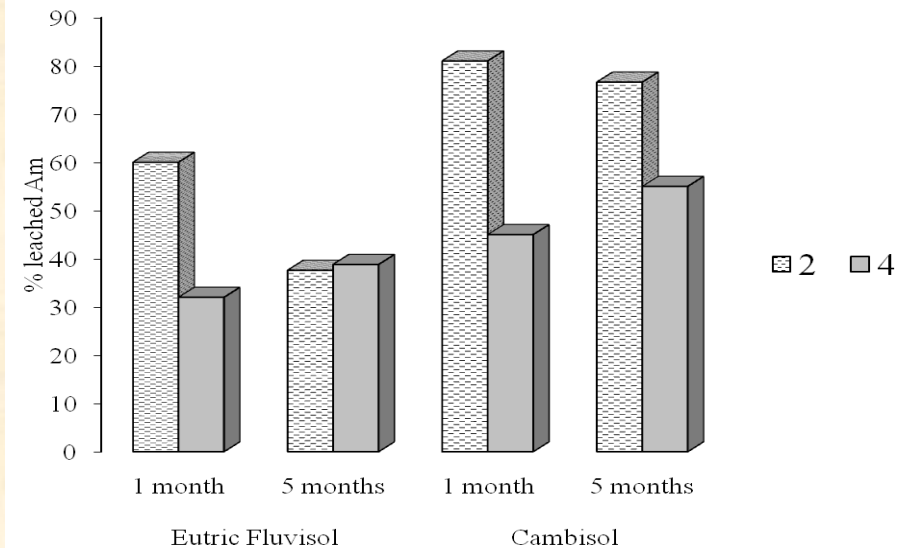
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Migration of natural and technogenic radionuclides in the environment

Soil moistures, % w/w and temperatures of conditioning of the contaminated soils

Conditions	Soil moisture, % <u>w/w</u>	Temperature, °C
1	22 ± 1	20 ± 3
2	0 ± 0.2	20 ± 3
3	22 ± 1	4 ± 0.5
4	22 ± 1	-18 ± 0.5

Total % leached ^{241}Am from Eutric Fluvisol and Cambisol by NIST procedure for sequential extraction after 1 and 5 months conditioning



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*Thank you for
your attention!*



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